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LIQUID CRYSTAL DISPLAY DEVICE

Application No. Sho 61(1986)-262,641

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Specification

1. Title of Invention

LIQUID CRYSTAL DISPLAY DEVICE

2. Scope of Patent Claim

1. A liquid crystal display device which is characterized by the fact that in a liquid crystal display device that has a liquid crystal panel of liquid crystals sandwiched between the counter-driving electrodes and the driving electrodes for picture images in dot-matrix form and where said liquid crystals are driven by the aforementioned driving electrodes and light is irradiated onto said liquid crystal panel to display an image,

there is an optical shaping means that shapes white light from the light source to approximately parallel light, a prism that is placed between the aforementioned optical shaping means and the aforementioned liquid crystal panel and resolves the white light from said optical shaping means into a spectrum, and a plane-type lens of many lenses on the same plane that is set up between the aforementioned prism and liquid crystal panel, and the red, blue and green lights obtained by resolution from the aforementioned prism are irradiated to the corresponding aforementioned driving electrodes for red, blue and green picture elements at the aforementioned liquid crystal panel.

2. A liquid crystal display device which is characterized by the fact that in the liquid crystal display device in item 1 of the Scope of Patent Claim, the aforementioned plane-type lens is made from lenticular lenses.

3. A liquid crystal display device which is characterized by the fact that in the liquid crystal display device in item 1 of the Scope of Patent Claim, the part of the aforementioned liquid crystal panel that is not to be irradiated by the

aforementioned light source is coated black.

4. A liquid crystal display device which is characterized by the fact that in the liquid crystal display device in item 2 of the Scope of Patent Claim, the aforementioned prism and lenticular lens are inclined in accordance with the position of the aforementioned driving electrodes for red, blue and green picture elements in the aforementioned liquid crystal panel.

3. Detailed Explanation of Invention

[Industrial field of application]

This invention pertains to a liquid crystal display device and in particular, to a liquid crystal display device that showed improved efficiency of light use.

[Conventional technology] [Prior art]

Liquid crystal display devices have become very popular because they are thin and have low electrical consumption. Since these liquid crystal display devices are not self-lighting, when viewing in a dark environment, or when it is necessary to obtain a brighter image plane, it is necessary to install a separate light source. Utility Model No. Sho 58(1983)-46,447 is an example of this type of structure. This structure is shown in Figure 13.

Light from light source 1 is irradiated onto liquid crystal 5 by light guide 2. In order to change the orientation of the liquid crystals corresponding to each picture element, bottom electrode plate 4 and top electrode plate 6 are placed on both sides of liquid crystal 5. The light passing from light guide 2 passes through polarizer 3 to become linear polarized light, and then this light passes through liquid crystal 5. The state of polarization of the light that passes through liquid crystal 5 is changed and then passed through polarizer 7, and the difference in this orientation can be monitored in terms of the brightness of the light.

However, a counter-driving electrode is set up in aforementioned top electrode plate 6 and a driving electrode for picture elements is set up in matrix-form for bottom electrode plate 4. The electrode in Japanese Kokai Patent No. Sho 59(1984)-60,469, for instance, can be used as bottom electrode plate 4. Each picture element has the structure shown in Figure 14. In Figure 14, 8 is the data signal line, 9 is the timing signal line, and 10 is the picture element driving electrode. Light is uniformly irradiated onto the surface. However, only light that is irradiated onto the picture element driving electrode is efficiently used. In general, the utilization efficiency of this light is 70%. However, the number of dots (picture elements) of the current liquid crystal display devices has been increased for higher resolution. The width of each signal line is limited to several microns by fabrication technology. As a result, the surface area percentage (aperture) of picture element driving electrodes is low and the light utilization efficiency is poor.

Moreover, in recent years liquid crystal display projectors have been produced where images from these liquid crystal display devices are enlarged with lenses to obtain an actual image on a separate screen. Since the light utilization efficiency of these devices is even worse because of the aforementioned lenses, there is a strong demand for devices with which a bright image can be obtained.

Moreover, when color display is performed, color filters corresponding to red (R), green (G) and blue (B) in accordance with each picture element are placed in top electrode plate 6 shown in Figure 13, as shown in Figure 15, that is, top electrode plate 6 made from a transparent electrode that serves as the aforementioned counter-driving electrode on a glass substrate. Glass filters are placed between this glass substrate and the transparent electrode. In this case, when uniform white light is irradiated onto the color filter, for instance, when R is

emphasized, of the white light, only the red spectrum distribution is transmitted and the other light is absorbed. This is also the same for G and B. Consequently, the transmittance of light when this color filter is used is generally approximately 20% and therefore, extreme light loss occurs.

[Problems solved by invention]

As previously mentioned, by means of conventional technology, white light is uniformly irradiated as is on the surface when color display is performed, and therefore, light loss of unnecessary wavelength occurs in the color filter. As a result, light utilization efficiency is poor and a bright image is not obtained. Moreover, when brightness is increased, large amounts of light must be input and therefore, the power of the light source must be increased and low energy consumption is not realized.

The objective of this invention is to solve the problems of the aforementioned conventional technologies and present a liquid crystal display device with which light utilization efficiency is improved and a bright image can be obtained and low energy consumption is possible by irradiating only the wavelength component of the corresponding light to the color filter.

[Means for solving problems]

In order to accomplish the aforementioned objective, by means of this invention there is an optical shaping means that shapes white light from the light source to approximately parallel light, a prism that is placed between the aforementioned optical shaping means and the aforementioned liquid crystal panel and resolves the white light from said optical shaping means into a spectrum, and a plane-type lens of many lenses comprised on the same plane that is set up between the aforementioned prism and liquid crystal panel, and the

red, blue and green lights obtained by resolution from the aforementioned prism are irradiated to the corresponding aforementioned driving electrodes for red, blue and green picture elements at the aforementioned liquid crystal panel.

[Effects]

By means of this invention, first, the white light from the light source is shaped to parallel light by the aforementioned optical shaping means. This white light is resolved into the spectrum, that is, red, blue and green, by the aforementioned prism. These lights of 3 different colors are irradiated onto the lens group of the aforementioned plane-type lens at the corresponding angle. The light that has been irradiated is focused by the lens group and irradiated onto each picture element driving electrode. Consequently, the light does not reach the signal line, etc., and can be efficiently used to realize a bright image plane.

Moreover, since the light of each color is parallel light, these lights are focused at different points, the corresponding red light, green light and blue light is irradiated onto the driving electrodes for red, green and blue picture elements, respectively.

Consequently, by using a color filter for the corresponding driving electrodes for red, green and blue picture elements, for instance, by using a red filter, only the red light will reach the electrode. Therefore, the amount of light absorbed by the red filter is kept to a minimum and the light can be efficiently used to obtain a bright image.

[Examples]

An example of this invention will now be explained while referring to Figure 1.

Figure 1 is a cross section showing an example of this invention.

In Figure 1, 11 is the light source, 12 is the parabolic reflector, 13 is the prism, 14 is the lenticular lens, 15 is the polarizer, 16 is the bottom electrode plate, 17 is the liquid crystal, 18 is the counter-driving electrode, 19 is the color filter, and 20 is the polarizer. Furthermore, the top electrode plate is made from counter-driving electrode 18 and color filter 19. In addition, a xenon lamp was used as the light source in this example.

As shown in Figure 1, light produced from light source 11 is converted to parallel light by parabolic reflector 12, and then the parallel light is resolved into the spectrum, that is, red, blue and green light, by prism 13. The front view of prism 13 is shown in Figure 2. As shown in Figure 2, prism 13 is a discontinuous prism that is long in the horizontal direction.

Next, light of each color that has been resolved by prism 13 is irradiated onto lenticular lens 14 at different angles. The focal point of lenticular lens 14 is approximately the surface of the picture element driving electrode of bottom electrode plate 16.

Figure 3 shows the path of the light in the prism and lenticular lens in Figure 1.

In Figure 3, 37, 38, and 39 are the red, green and blue lights, respectively.

As shown in Figure 3, each light is irradiated onto prism 13 in a parallel state. The red, blue and green lights are not parallel after passing through the prism and have a specific angle θ_1, and θ_2. When the focal distance of lenticular lens 14 is f_1 and f_2 (the focal distance of lenticular lens 14 is wavelength-dependent and the focal distance is different for red and blue lights), each light is separated by d_1 and d_2 given by the following formulas:

$$d_1 = f_1 \cdot \theta_1, d_2 = f_2 \cdot \theta_2$$

Figure 4 is a diagram of the flux irradiated onto the surface of the picture element driving electrode of the bottom electrode plate in Figure 1.

Furthermore, Figure 4 shows the inside of the electrode plate in Figure 1 at a 90° turn.

In Figure 4, 21, 22, and 23 are the positions of the red, green and blue filters, respectively, in color filter 19 shown in Figure 1. Moreover, 24, 25 and 26 show the respective flux focused on this electrode surface. 24 is red light, 25 is green light and 26 is blue light.

As shown in Figure 4, red light 24 that has been irradiated onto the picture element driving electrode then passes through the red filter and therefore, little light is absorbed. The light that is irradiated onto the red filter in conventional examples is white light, and the blue and green components of this light are absorbed by the filter. Light utilization efficiency is markedly improved when compared to this conventional case. Although light transmittance of the filter is 20% with conventional devices, it is 60% with this example, for an improvement in efficiency of approximately 3 times.

Furthermore, in this example there is no regard to the relationship between each sub-prism comprising prism 13 and each microlens comprising lenticular lens 14 with respect to position in the direction perpendicular to the image plane; in other words, there can be any relationship between pitch of the sub-prisms of prism 13 and pitch of the microlenses of the lenticular lens14. Moreover, although theoretically the device can be operated with any relationship between the microlenses of lenticular lens 14 and the picture element driving electrode of bottom electrode plate 16 in terms of their direction perpendicular to the image plane, actually, it is preferred that the device be made so that the three picture elements for red, green and blue correspond to

one microlens, as shown in Figure 3.

Another example will now be explained using Figures 5 and 6.

The structure of this example is approximately the same as that shown in Figure 1. However, the filters for red, green and blue of color filter 19 that are used are set up differently, and the positions of prism 13 and lenticular lens 14 are different.

Figure 5 shows the flux irradiated to the surface of the picture element driving electrode of the bottom electrode plate in another example of this invention.

In Figure 5, 27, 28 and 29 are the positions of red, green and blue filters, respectively, of color filter 19 in this example. Moreover, 30, 31 and 32 are the respective red, green and blue lights.

In this example, the apparent resolution, particularly resolution in the horizontal direction of the image plane, can be improved, regardless of the number of picture elements, when compared to the filter position used in the aforementioned example and shown in Figure 4 by placing the red, green and blue filters of color filter 19 as shown in Figure 5. Moreover, in this case, lenticular lens 14 is inclined in its lengthwise direction, as shown in Figure 6. By using this type of structure, the light on the picture element driving electrode is focused as shown in Figure 5. Moreover, in this case the degree of separation of each color can be improved by inclining prism 13, which is a discontinuous prism, in accordance with the direction of lenticular lens 14 or color filter 19.

Next, a different example of this invention will be explained using Figure 7.

Although the general structure in this example is the same as that shown in Figure 1, it is different in that color filter 19 is not employed.

Figure 7 shows the flux irradiated onto the surface of the picture element

driving electrode of the bottom electrode plate of a different example of this invention.

In Figure 7, 30, 31 and 32 are the red, green and blue lights that are focused. 33, 34, and 35 show each picture element and correspond to the red, green and blue picture driving electrodes, respectively.

That is, by means of this example, complete color resolution is accomplished, as shown in Figure 7, by prism 13 and lenticular lens 14 and therefore, color images can be reproduced without using color filter 19. Consequently, colorization is simple and there is an advantage in that inexpensive liquid crystal panels can be made.

Furthermore, the matrix lens shown in Figure 8 can be used in place of lenticular lens 14 in the aforementioned example. When this type of lens is used, the flux can be constricted to dots or circles and therefore, utilization efficiency of light is improved even further.

Figure 9 is a front view of the color filter used in still another example of this invention and Figure 10 shows the front view of the lenticular lens used with the color filter in Figure 9.

The overall structure of this example is approximately the same as the example in Figure 1, but the position of the red, green and blue filters of color filter 19 that is used are different and are as shown in Figure 9. In this case, it is necessary to incline lenticular lens 14 as shown in Figure 10.

Thus, by means of this example, the same results as in the examples shown in Figures 5 and 6 are obtained.

Moreover, by means of this example, a dragonfly lens can be used, as shown in Figure 11. This dragonfly lens has micro-lenses in each block 40. The light can be constricted finely at the surface of the picture element driving electrode, as shown in Figure 12, by using this dragonfly lens and prism 13. 41,

42, and 43 in Figure 12 show the constricted red, green and blue lights, respectively.

When this type of device is used, reflectivity for outside light can be minimized and contrast can be improved by a black coating of region 44, where light is not to be irradiated.

In addition to cases where the dragonfly lens is used, reflectivity for outside light can be minimized and contrast can be improved by a similar black coating of the region that is not be to irradiated when the aforementioned lenticular lens and matrix lens are employed.

[Results of invention]

By means of this invention, light is efficiently irradiated from a light source onto the picture element driving electrode, and only the wavelength component of light that corresponds to the color filter can be irradiated. Therefore, the light utilization efficiency can be improved to obtain a brighter image. Moreover, an energy-saving liquid crystal display device can be realized. For instance, although the transmittance of a single color filter of conventional devices is approximately 20%, by means of this invention, it can be markedly improved to approximately 60%. Moreover, if light can be completely separated by a prism and lenticular lens, etc., a simplification of the structure and a reduction in cost can be accomplished because a color filter is not used.

Furthermore, when the part that is not to be irradiated is coated black, reflectivity for external light is minimized and contrast is further improved.

4. Brief Explanation of Figures

Figure 1 is a cross section of an example of this invention, Figure 2 is a front view of the prism in Figure 1, Figure 3 is a diagram showing the path of

light through the prism and lenticular lens in Figure 1, Figure 4 shows the flux irradiated onto the picture element driving electrode of the bottom electrode plate of Figure 1, Figure 5 shows the flux irradiated onto the picture element driving electrode of the bottom electrode plate in another example of this invention, Figure 6 is a front view of the lenticular lens used in another example of this invention, Figure 7 shows the flux irradiated onto the picture element driving electrode of the bottom electrode plate of a different example of this invention, Figure 8 is a front view showing the matrix lens used in place of the lenticular lens, Figure 9 is a front view showing the color filter used in yet another example of this invention, Figure 10 is a front view of the lenticular lens used with the color filter in Figure 9, Figure 11 is a front view of the dragonfly lens used in place of the lenticular lens in Figure 10, Figure 12 shows the flux irradiated onto the surface of the picture element driving electrode of the bottom electrode plate when the dragonfly lens in Figure 11 was used, Figure 13 is a cross section showing a conventional liquid crystal display device, Figure 14 is a front view showing the structure of each picture element at the bottom electrode plate in Figure 13, and Figure 15 is a front view of the color filter used when color display is performed in Figure 13.

Definition of symbols:

11. light source

12. parabolic reflector

13. prism

14. lenticular lens

15, 20: polarizers

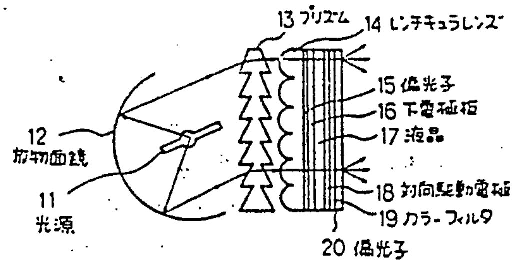
16. bottom electrode plate

17. liquid crystal

18. counter-driving electrode

19. color filter

Figure 1.



11. light source
12. parabolic reflector
13. prism
14. lenticular lens
15. polarizer
16. bottom electrode plate
17. liquid crystal
18. counter driving electrode
19. color filter
20. polarizer

第 2 図

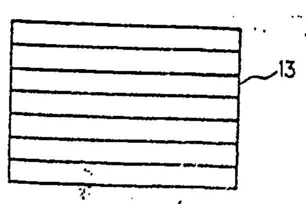


Figure 2

第3図

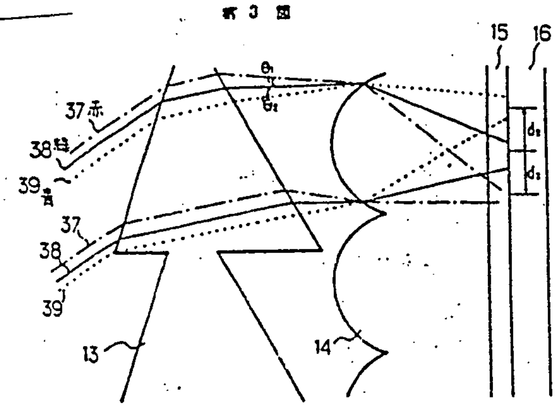
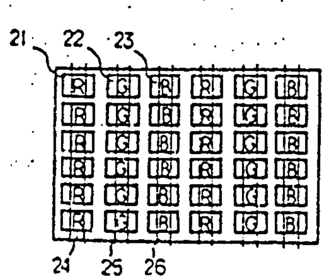
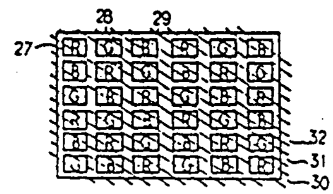


Figure 3
37. red
38. green
39. blue

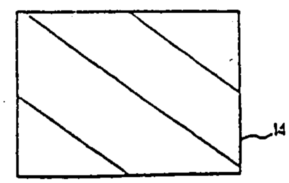
第4図



第5図



第6図



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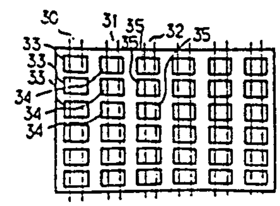

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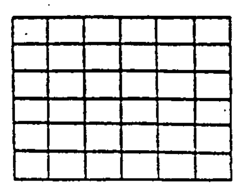

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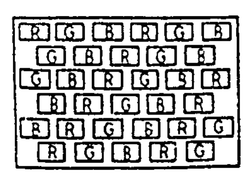
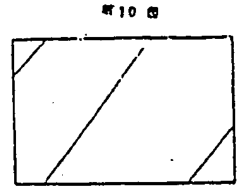
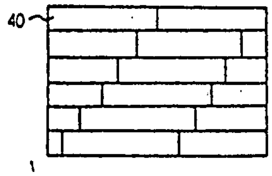


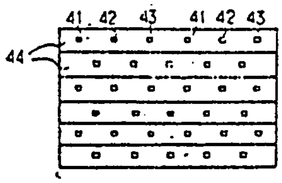
第10図



第11図



第12図



第13図

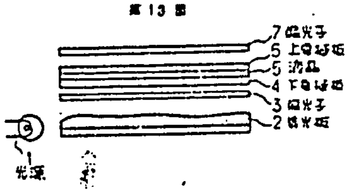


Figure 13.

1. light source
2. light guide
3. polarizer
4. bottom electrode plate
5. liquid crystal
6. top electrode plate
7. polarizer

第14図

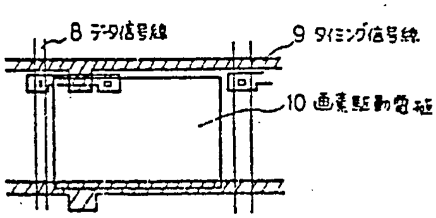


Figure 14.

8. data signal line
9. timing signal line
10. picture element driving electrode

第15図